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May 25, 1999

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TITLE: Composite for heat sink, semiconductor devices and wiring board - is obtained by impregnating metal into porous ceramic structure

PATENT-ASSIGNEE: DENKI KAGAKU KOGYO KK (ELED)

PRIORITY-DATA: 1997JP-0310292 (November 12, 1997)

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ABSTRACTED-PUB-NO: JP11140560A

BASIC-ABSTRACT:

NOVELTY - The composite is formed by impregnating a metal into a porous ceramic structure. The metal freezing point temperature is 50 deg. C and the freezing point falls at the rate of 1-20 deg. C/hour under pressure application.

USE - For heat sink, semiconductor devices, integrated circuit boards, multilayer wiring board and industrial purposes.

ADVANTAGE - The composite has good heat conductivity, strength and thermal coefficient of expansion. The composite is stable and the process of manufacture is economical.

ABSTRACTED-PUB-NO: JP11140560A

EQUIVALENT-ABSTRACTS:

CHOSEN-DRAWING: Dwg.0/0

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**HIROTSURU HIDEKI****(54) PRODUCTION OF COMPOSITE BODY****(57) Abstract:**

**PROBLEM TO BE SOLVED:** To suitably use the composite body for a heat sink for a semiconductor device, such as a IC package and wiring board, by impregnating metal into a porous ceramic structure under pressure, at a temp. in a specific range, at a specific rate of temperature decrease.

**SOLUTION:** Cooling velocity, within the region between the solidification point of the metal to be impregnated into the porous ceramic structure and a temp. higher by 50°C than the solidification point, is regulated to a temp.-fall rate of (1 to 20)°C/hr. By this procedure, the

microstructure of the resultant composite body can be stabilized and reproducibility can be provided, and as a result, the composite body having stable physical properties can be obtained with superior reproducibility in high yield. When silicon carbide, aluminum nitride, silicon nitride, alumina, etc., having high thermal conductivity and low coefficient of thermal expansion, are used for the above ceramic structure, the composite body suitable for a heat sink for semiconductor circuit board can be obtained. Further, it is preferable to use, as the metal to be impregnated, light metal, such as Al and Mg, or alloys thereof for the purpose of attaining high thermal conductivity and lightweight characteristic.

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(54) 【発明の名称】 複合体の製造方法

(57) 【要約】

【課題】 安定した低熱膨張率、高熱伝導率を有し、セラミック回路基板用ヒートシンクに好適な複合体を提供する。

【解決手段】 多孔質セラミックス構造体に金属を含浸する際、或いは含浸後に、前記金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内を、加圧下、1～20℃/Hrの降温速度とすることを特徴とする複合体の製造方法。

## 【特許請求の範囲】

【請求項1】 多孔質セラミックス構造体に金属を含浸する複合体の製造方法であって、前記金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内を、加圧下、1～20℃/Hrの降温速度で含浸することを特徴とする複合体の製造方法。

【請求項2】 多孔質セラミックス構造体に金属を含浸してなる複合体を、前記金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内を、加圧下、1～20℃/Hrの降温速度で処理することを特徴とする複合体の製造方法。

【請求項3】 多孔質セラミックス構造体が炭化珪素、窒化アルミニウム、窒化珪素、アルミナ又はシリカからなる群より選ばれる1種以上からなることを特徴とする請求項1又は請求項2記載の複合体の製造方法。

【請求項4】 金属がアルミニウム又はマグネシウムのいずれかを主成分とすることを特徴とする請求項1、請求項2又は請求項3記載の複合体の製造方法。

【請求項5】 前記多孔質セラミックス構造体が空隙率20～50%の炭化珪素からなり、前記金属がアルミニウムを主成分とすることを特徴とする請求項1、請求項2、請求項3又は請求項4記載の複合体の製造方法。

## 【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、ICパッケージや多層配線基板等の半導体装置のヒートシンクに好適な、金属或いは合金とセラミックスとからなる複合体（以下、「金属—セラミックス複合体」又は単に「複合体」という）の製造方法に関する。

【0002】

【従来の技術】 半導体分野において、LSIの集積化や高速化がすすむことに加え、近年GTOやIGBT等のパワーデバイスの用途が拡大するなど、シリコンチップの発熱量は増加の一途をたどっている。それとともにシリコンチップから発熱した熱を逃がす回路基板、更にヒートシンクについても、より一層の高性能化が求められている。

【0003】 具体的には、回路基板については熱伝導性の良いアルミナ、窒化アルミニウム、窒化珪素等のセラミックス回路基板が用いられているし、これに接合して用いられるヒートシンク自体の熱伝導率が高いものが用いられる。更に、両者が組み合わされモジュール化された場合においては、前記回路基板とヒートシンクとの熱膨張率が近いことが望まれる。これは、実使用時に半導体素子から発生する熱等に原因して、発生した熱応力が回路基板を破壊し、回路基板の電気絶縁性や熱伝導性を劣化させ、モジュールとしての信頼性を低下させる原因になってしまうからである。

【0004】 上記の事情により、電気、或いは自動車などの車両用途等の高信頼性が重要とされる分野におい

て、金属—セラミックス複合体（以下、複合体という）のヒートシンクへの適用が熱膨張率がセラミックス回路基板に近いという理由で進められている（特開昭64-83634号公報、特開平9-209058号公報）。

【0005】 前記複合体は、一般に、セラミックス粉、セラミックス繊維などを成形、必要な場合においては焼成して、多孔質セラミックス構造体を作製し、次に熔融金属を含浸し、これを冷却することにより作製される。熔融金属を含浸する方法としては、粉末冶金法に基づく方法、例えばダイキャスト法（特開平5-508350号公報）や溶湯鍛造法（まてりあ、第36巻、第1号、1997、40-46ページ）などの高圧鑄造による方法、自発浸透による方法（特開平2-197368号公報）等の各種の方法が知られている。

【0006】

【発明が解決しようとする課題】 しかし、上記の従来公知の方法で得られた金属—セラミックス複合体においては、熔融金属とセラミックスとが濡れにくいこと、セラミックス構造体中の気孔形状が安定しないこと、熔融金属の冷却条件が安定しないこと等が原因してか、得られる金属—セラミックス複合体の微細組織が不安定であり、その結果特性の安定した複合体が容易に得難いという問題がある。

【0007】 本発明者らは、上記問題点を解決し、半導体素子を搭載するセラミックス回路基板に適用した際に、実使用下でセラミックス回路基板が熱衝撃で破損する等の問題を生じず、また十分に熱伝導性に優れ半導体素子が誤動作し難い、高信頼性のヒートシンクを提供するべく検討した結果、本発明に至ったものである。

【0008】

【課題を解決するための手段】 本発明は、多孔質セラミックス構造体に金属を含浸する複合体の製造方法であって、前記金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内について、加圧下、1～20℃/Hrの降温速度で含浸することを特徴とする複合体の製造方法である。また、本発明は、多孔質セラミックス構造体に金属を含浸してなる複合体を、前記金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内について、加圧下、1～20℃/Hrの降温速度で処理することを特徴とする複合体の製造方法である。

【0009】 本発明は、多孔質セラミックス構造体が炭化珪素、窒化アルミニウム、窒化珪素、アルミナ又はシリカからなる群より選ばれる1種以上からなることを特徴とする前記の複合体の製造方法であり、好ましくは、金属がアルミニウム、又はマグネシウムのいずれかを主成分とすることを特徴とする前記の複合体の製造方法であり、更に好ましくは、前記多孔質セラミックス構造体が空隙率20～50%の炭化珪素からなり、前記金属がアルミニウムを主成分とすることを特徴とする前記の複合体の製造方法である。

## 【0010】

【発明の実施の形態】本発明者らは、低熱膨張率で、しかも高熱伝導率の金属—セラミックス複合体を安定して得るために、その製造条件について検討した結果、多孔質セラミックス構造体中で熔融金属が凝固する時の特定温度範囲での冷却条件が重要であり、該特定温度範囲での冷却速度を十分に遅くすることで、再現性のある微構造が達成でき、その結果として特性の安定した金属—セラミックス複合体が得られるという知見に基づき、本発明を完成したものである。

【0011】前記特定の温度範囲とは、発明者らの実験的検討結果に基づけば、多孔質セラミックス構造体中に含浸する金属（或いは合金）の凝固点温度を下限とし、上限は該凝固点温度より50℃までの温度範囲である。ここで、凝固点温度とは、液相状態の熔融金属が完全に固相となる温度であり、例えば、純アルミニウムの場合では融点の660℃、アルミニウム—シリコン系の合金の場合では共晶温度の577℃である。尚、凝固点温度より50℃を越える温度から温度制御を開始しても、また凝固点温度以下まで制御を続けてもよいが、更なる特性安定の効果は期待できず、むしろ生産性の低下になるので効果的でない。

【0012】本発明では、前記特定範囲、即ち金属の凝固点温度と前記凝固点温度より50℃高い温度との範囲内の冷却速度を、1~20℃/Hrの降温速度とすることを特徴とする。前記温度範囲内を特定の冷却速度で制御するとき、得られる複合体の微構造は安定し、再現性を有し、その結果として、物性値の安定した複合体を再現性良く、高い歩留まりで、従って生産性良く得ることができる。降温速度の制御条件については、20℃/Hrを越える降温速度では、特性安定の効果は得られないことがある。また、冷却速度の下限については、特に制限するものではないが、1℃/Hr未満の降温速度では、更なる特性安定の効果は得ず、むしろ生産性の低下になるので効果的でない。

【0013】前記特定温度範囲における圧力条件については、加圧されていれば良く、また本発明の目的を達成する上からは前記圧力に上限を設ける必要はない。しかし、200MPaを越えると、多孔質セラミックス複合体に割れ、ヒビ等が生じる場合があり、好ましくない。し、0.5MPa未満でも特性の安定化が十分でない場合があり、0.5MPa~200MPaが好ましい範囲として選択される。更に実用的には1~100MPaが最も良好な範囲として選択される。

【0014】上記特定温度範囲で、加圧下で特定の冷却速度で、多孔質セラミックス構造体中に熔融金属を冷却、凝固させ、低熱膨張率と高熱伝導率を安定的に発現させることは、必ずしも含浸操作に限定されず、一度含浸操作を経て得られた金属—セラミックス複合体について適用することもできる。しかし、本発明の特定の温度

範囲内を加圧下で特定の冷却速度とする処理を、含浸操作に引き続いて適用することが生産性の面で好ましい。更に、含浸操作を加圧下で行うダイキャスト法や溶湯鍛造法等の高圧鑄造法の場合には、温度条件を制御するのみで良く、操作性に優れ、好ましい。又、一度含浸操作を経て得られた金属—セラミックス複合体について適用する場合、上記操作を雰囲気加圧装置等を用いて、アルゴン、ヘリウム等の希ガス、或いは窒素等の非反応性ガス相の存在下で上記処理を行うこともできる。

10 【0015】本発明の多孔質セラミックス構造体は、金属或は合金を含浸させることが可能な開放気孔を有し、しかも含浸操作において破壊することのない機械的強度を有する構造体であれば、どのようなものでも構わない。しかし、金属—セラミックス複合体を半導体回路基板用ヒートシンクに適用する場合、金属—セラミックス複合体の熱伝導率が高く、また温度上昇に伴って低下し難いこと、また熱膨張係数をアルミナ、窒化アルミニウム、窒化珪素等のセラミック回路基板と同程度に小さいことが必要であるということから、高熱伝導でありかつ  
20 低熱膨張率の炭化珪素、窒化アルミニウム、窒化珪素並びにアルミナ等が好適である。

【0016】又、シリカは、熱伝導率は前記セラミックスよりも小さいものの、熱膨張係数が小さいため、少ない添加量で金属—シリカ複合体の熱膨張係数をセラミック基板の熱膨張係数に近づけることができるという特徴がある。一般に、金属—セラミックス複合体に関して、その熱伝導率の温度依存性については、該複合体中のセラミックス含有量が大いほど著しく低下するが、前記の特徴から、シリカを用いて得られる複合体は温度上昇  
30 時の熱伝導率の低下が少なく、前記セラミックスを使用したときと同様の効果をえることができるので、やはり好ましい。

【0017】上述したセラミックスのうち、炭化珪素はそれ自体の熱伝導率が、高熱伝導率の金属であるアルミニウムのそれよりも高く、炭化珪素を使用する場合には、金属単体の熱伝導率よりも高い熱伝導率を有する金属—セラミックス複合体を得ることができるので、特に好ましく選択される。

【0018】本発明に用いる金属については、本発明の  
40 目的を達成することができれば、どのようなものであっても構わないが、高熱伝導性、軽量性を達成する目的から、アルミニウム、マグネシウム等の軽合金又はそれらの合金が好ましい。アルミニウム合金の場合には、鑄造のしやすさ、高熱伝導性の発現の点からSi含有量が4~10%のAC2A、AC2B、AC4A、AC4B、AC4C、AC8B、AC4D、AC8C、ADC10、ADC12等の合金が特に好ましい。

【0019】上記のセラミックスと金属の組合せに関して、金属としてアルミニウム或いはアルミニウム系合  
50 金、セラミックスとして炭化珪素を用いたアルミニウム

一炭化珪素複合体は、軽量、高熱伝導、セラミック基板との熱膨張率の適合性の点で特に優れた組合せである。本発明者らは、このアルミニウム-炭化珪素複合体について、更にいろいろ検討した結果、炭化珪素含有量には本発明の目的を達するのに好適な範囲が存在することを見だし、本発明に至ったものである。即ち、アルミニウム-炭化珪素複合体中の炭化珪素含有量が50体積%未満では熱膨張係数が高くなることもあり、この場合には、セラミック基板との熱膨張率差に起因する前記問題が生じ易くなる。また、セラミックスが高温で熱伝導率を低下させることに原因して、80体積%を越える炭化珪素含有量の場合では、半導体搭載用回路基板のヒートシンクとして用いた時に、実使用時の半導体素子等からの発熱による温度上昇によって、熱伝導率の低下が著しくなるという問題が顕著になってくる。以上の理由から、アルミニウム-炭化珪素複合体中の炭化珪素含有量は50~80体積%が好ましく、そして、前記条件を達成するために、多孔質炭化珪素の構造体の気孔率は50~20体積%が好適である。

【0020】以下、実施例及び比較例に基づき、本発明を更に詳細に説明する。

【0021】

【実施例】 【実施例1】 平均粒径50 $\mu$ mの炭化珪素にバインダーとしてシリカゾルを固形分濃度で5wt%混

合し、プレス成形した後空气中900℃で2時間焼成し、大きさ35mm×35mm×3mm、気孔率40%の多孔質炭化珪素構造体を作製した。

【0022】次に、内径50mm、肉厚25mmの金型を用意し、該金型外表面から深さ20mmの孔を設け、該孔中に金型内表面温度測定用熱電対をセットした。この金型をバーナーで加熱し、金型の内面温度の接触温度計による実測値と、その際の金型内表面温度測定用熱電対の測定値に差がないことを確認した。

10 【0023】前記の多孔質炭化珪素構造体を800℃で予熱した後、バーナー加熱により内面温度を710℃に保持した前記金型に入れ、900℃で溶融した純アルミニウムを金型に流し込み、押し棒をセットし、100MPaの圧力で加圧した。

【0024】加圧状態のまま冷却し、金型内表面温度測定用熱電対の測定値を見ながらバーナーの強さを調整し、710℃から660℃までの降温速度を10℃/Hrに制御し、660℃でバーナーを切り100℃まで冷却したところで加圧を終了した。

20 【0025】同一の方法でアルミニウム-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定した。この結果を表1に示す。

【0026】

【表1】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例1-1	205	$8.7 \times 10^{-6}$	302
実施例1-2	203	$8.8 \times 10^{-6}$	305
実施例1-3	206	$8.9 \times 10^{-6}$	301

【0027】 【実施例2】 溶融金属の流し込み時の金型の内面温度が627℃、降温速度を制御した温度範囲が627~577℃、金属がアルミニウム-6wt%シリコン合金、該合金の溶融温度が800℃であること以外は実施例1と同一の方法でアルミニウム合金-炭化珪素

複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、その結果を表2に示した。

【0028】

【表2】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例2-1	196	$7.8 \times 10^{-6}$	360
実施例2-2	193	$7.9 \times 10^{-6}$	362
実施例2-3	195	$7.7 \times 10^{-6}$	358

【0029】 【実施例3】 降温速度が20℃/Hrであること以外は実施例2と同一の方法でアルミニウム合金

一炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、その結果を表3に示した。

【0030】  
【表3】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例3-1	197	$8.1 \times 10^{-6}$	350
実施例3-2	195	$8.0 \times 10^{-6}$	341
実施例3-3	195	$7.9 \times 10^{-6}$	349

【0031】【実施例4】圧力が200MPaであること以外は実施例2と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、表4に示す結果

を得た。  
【0032】  
【表4】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例4-1	201	$8.3 \times 10^{-6}$	345
実施例4-2	204	$8.0 \times 10^{-6}$	348
実施例4-3	203	$8.1 \times 10^{-6}$	346

【0033】【実施例5】圧力が0.5MPaであること以外は実施例2と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、表5に示す結果

を得た。  
【0034】  
30 【表5】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例5-1	199	$8.1 \times 10^{-6}$	345
実施例5-2	200	$8.0 \times 10^{-6}$	348
実施例5-3	197	$7.9 \times 10^{-6}$	346

【0035】【実施例6】圧力が220MPaであること以外は実施例4と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、表6に示す結果

を得た。  
【0036】  
【表6】



	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
実施例6-1	192	$8.3 \times 10^{-6}$	345
実施例6-2	190	$8.1 \times 10^{-6}$	348
実施例6-3	180	$8.9 \times 10^{-6}$	332

【0037】【比較例1】650℃～600℃までの降温速度を10℃/Hr、600℃以下の降温速度を25℃/Hr以上としたこと以外は実施例2と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を

測定し、表7に示す結果を得た。実施例2と比較して、熱伝導率、熱膨張係数及び強度が安定しないことが明らかとなった。

【0038】

【表7】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
比較例1-1	190	$8.1 \times 10^{-6}$	340
比較例1-2	160	$8.9 \times 10^{-6}$	302
比較例1-3	158	$9.2 \times 10^{-6}$	310

【0039】【比較例2】600℃～550℃までの降温速度を10℃/Hr、550℃以下の降温速度を25℃/Hr以上としたこと以外は実施例2と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を

測定し、表8に示す結果を得た。実施例2と比較して、熱伝導率、熱膨張係数及び強度が安定しないことが明らかとなった。

【0040】

【表8】

	熱伝導率 W/(m·K)	熱膨張係数 1/K	三点曲げ強度 MPa
比較例2-1	195	$7.9 \times 10^{-6}$	350
比較例2-2	192	$8.0 \times 10^{-6}$	310
比較例2-3	194	$7.9 \times 10^{-6}$	328

【0041】【比較例3】降温速度が25℃/Hrであること以外は実施例3と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、表9に示す

結果を得た。実施例3と比較して、熱伝導率、熱膨張係数及び強度が安定しないことが明らかとなった。

【0042】

【表9】

	熱伝導率 $W/(m \cdot K)$	熱膨張係数 $1/K$	三点曲げ強度 MPa
比較例3-1	188	$8.1 \times 10^{-6}$	352
比較例3-2	152	$9.0 \times 10^{-6}$	313
比較例3-3	160	$9.2 \times 10^{-6}$	301

【0043】【比較例4】圧力が常圧(0.1MPa)であること以外は実施例5と同一の方法でアルミニウム合金-炭化珪素複合体を3サンプル作製し、得られた複合体の熱伝導率、熱膨張係数及び強度を測定し、表10

に示す結果を得た。実施例5と比較して、熱伝導率、熱膨張係数及び強度が安定しないことが明かとなった。

【0044】

【表10】

	熱伝導率 $W/(m \cdot K)$	熱膨張係数 $1/K$	三点曲げ強度 MPa
比較例4-1	148	$8.1 \times 10^{-6}$	349
比較例4-2	182	$8.5 \times 10^{-6}$	328
比較例4-3	157	$8.2 \times 10^{-6}$	316

【0045】

【発明の効果】本発明によれば、熱伝導率、熱膨張係数及び強度等の特性が安定した金属-セラミックス複合体を歩留まり高く製造することができ、信頼性の高い金属-セラミックス複合体を安定して安価に提供できるので、産業上極めて有用である。

【0046】本発明の方法で製造された金属-セラミッ

クス複合体は、その高熱伝導性、低熱膨張性及び軽量性の点から、特に電子部品の放熱部品として、セラミックス回路基板のヒートシンク材として好適である。

【0047】本発明の金属-セラミックス複合体は、その軽量性と力学的特性から、ヒートシンク用途以外の、例えば運輸、航空分野での金属代替材料用途にも有用である。

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## (54) PRODUCTION OF COMPOSITE BODY

### (57)Abstract:

PROBLEM TO BE SOLVED: To suitably use the composite body for a heat sink for a semiconductor device, such as a IC package and wiring board, by impregnating metal into a porous ceramic structure under pressure, at a temp. in a specific range, at a specific rate of temperature decrease.

SOLUTION: Cooling velocity, within the region between the solidification point of the metal to be impregnated into the porous ceramic structure and a temp. higher by 50°C than the solidification point, is regulated to a temp.-fall rate of (1 to 20)°C/hr. By this procedure, the microstructure of the resultant composite body can be stabilized and reproducibility can be provided, and as a result, the composite body having stable physical properties can be obtained with superior reproducibility in high yield. When silicon carbide, aluminum nitride, silicon nitride, alumina, etc., having high thermal conductivity and low coefficient of thermal expansion, are used for the above ceramic structure, the composite body suitable for a heat sink for semiconductor circuit board can be obtained. Further, it is preferable to use, as the metal to be impregnated, light metal, such as Al and Mg, or alloys thereof for the purpose of attaining high thermal conductivity and lightweight characteristic.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the manufacture method of the complex (the following and "metal-ceramic complex" -- or it is only called "complex") which consists of the metal or the suitable alloy, and suitable ceramics for a heat sink of semiconductor devices, such as an IC package and a multilayer-interconnection substrate

[0002]

[Description of the Prior Art] In addition to integration and improvement in the speed of LSI progressing, in the semiconductor field, the increase of the calorific value of a silicon chip is being enhanced -- the use of power devices, such as GTO and IGBT, is expanded in recent years. The circuit board which misses the heat which generated heat from the silicon chip with it, and highly efficient-ization still much more also about a heat sink are called for.

[0003] What has the high thermal conductivity of the heat sink itself which the ceramic circuit boards, such as a thermally conductive good alumina, aluminum nitride, and a silicon nitride, are used, and is specifically joined and used for this about the circuit board is used. Furthermore, when both are put together and a modularization is carried out, it is desired for the coefficient of thermal expansion of the aforementioned circuit board and a heat sink to be near. This is because it results from the heat generated from a semiconductor device at the time of real use and the generated thermal stress becomes the cause of destroying the circuit board, degrading the electric insulation of the circuit board, and thermal conductivity, and reducing the reliability as a module.

[0004] According to the above-mentioned situation, application to the heat sink of metal-ceramic complex (henceforth complex) is advanced in the field by which high-reliability, such as vehicles uses, such as electrical and electric equipment or an automobile, is made important by the reason coefficient of thermal expansion is close to the ceramic circuit board (JP,64-83634,A, JP,9-209058,A).

[0005] The aforementioned complex calcinates ceramic powder, ceramic fiber, etc., when required, fabrication and, generally, it produces the porosity ceramic structure, next sinks in molten metal and is produced by cooling this. As a method of sinking in molten metal, various kinds of methods, such as a method by high pressure casting, such as the method based on powder-metallurgy processing, for example, pressure die casting, (JP,5-508350,A), and a forging cast process (1997 wait \*\*\*\*, the 36th volume, No. 1, 40 -46 pages), and a method (JP,2-197368,A) by spontaneous osmosis, are learned.

[0006]

[Problem(s) to be Solved by the Invention] however, the cooling conditions of molten metal are not stabilized [ that molten metal and ceramics cannot get wet easily in the metal-ceramic complex obtained by the above-mentioned conventionally well-known method, that the pore configuration in the ceramic structure is not stabilized, ] -- resulting -- the detailed organization of the metal-ceramic complex obtained is unstable, and there is a problem [ complex / whose property was stable as a result ] are difficult to get, easily

[0007] This invention persons result in this invention, as a result of inquiring to offer the highly reliable

heat sink with which the above-mentioned trouble is solved, and the problem of the ceramic circuit board being damaged by the thermal shock under real use when it applies to the ceramic circuit board which carries a semiconductor device is not produced, and it fully excels in thermal conductivity, and a semiconductor device cannot malfunction easily.

[0008]

[Means for Solving the Problem] this invention is the manufacture method of the complex which sinks a metal into the porosity ceramic structure, and is the manufacture method of the complex characterized by sinking in under pressurization at the temperature fall speed of 1-20 degrees C/Hr about within the limits of the congealing-point temperature of the aforementioned metal, and temperature higher 50 degrees C than the aforementioned congealing-point temperature. Moreover, this invention is the manufacture method of the complex characterized by processing under pressurization the complex which comes to sink into the porosity ceramic structure in a metal at the temperature fall speed of 1-20 degrees C/Hr about within the limits of the congealing-point temperature of the aforementioned metal, and temperature higher 50 degrees C than the aforementioned congealing-point temperature.

[0009] The porosity ceramic structure this invention A silicon carbide, alumimium nitride, It is the manufacture method of the aforementioned complex characterized by the bird clapper from one or more sorts chosen from the group which consists of a silicon nitride, an alumina, or a silica. preferably It is the the manufacture method of the aforementioned complex characterized by a metal making either aluminum or magnesium a principal component. still more preferably It is the manufacture method of the aforementioned complex characterized by for the aforementioned porosity ceramic structure consisting of a silicon carbide of 20 - 50% of voidage, and the aforementioned metal making aluminum a principal component.

[0010]

[Embodiments of the Invention] In order that this invention persons are low coefficient of thermal expansion, may be stabilized and may moreover get the metal-ceramic complex of high temperature conductivity By the cooling conditions in a specific temperature requirement in case molten metal solidifies being important in the porosity ceramic structure, as a result of examining the manufacture condition, and making late enough the cooling rate in this specific temperature requirement A reproducible microstructure can be attained and this invention is completed based on the knowledge that the metal-ceramic complex whose property was stable as the result is obtained.

[0011] If the aforementioned specific temperature requirement is based on artificers' experimental examination result, congealing-point temperature of the metal (or alloy) which sinks in into the porosity ceramic structure will be made into a minimum, and an upper limit will be a temperature requirement to 50 degrees C from this congealing-point temperature. Here, congealing-point temperature is temperature from which the molten metal of a liquid phase state serves as solid phase completely, for example, is 577 degrees C of an eutectic temperature in the case of a pure aluminium at the case of 660 degrees C of the melting point, and the alloy of an aluminum-silicon system. In addition, even if it starts a temperature control from the temperature which exceeds 50 degrees C from congealing-point temperature, although control may be continued below to congealing-point temperature, since the effect of the further property stability cannot be expected but becomes the fall of productivity rather, it is not effective.

[0012] In this invention, it is characterized by making the cooling rate within the limits of the congealing-point temperature of the aforementioned specific range, i.e., a metal, and temperature higher 50 degrees C than the aforementioned congealing-point temperature into the temperature fall speed of 1-20 degrees C/Hr. When controlling the inside of the aforementioned temperature requirement by the specific cooling rate, the microstructure of the complex obtained is stabilized, has repeatability, as the result, its repeatability is good, and is a high yield, therefore can obtain the complex whose physical-properties value was stable with sufficient productivity. About the control condition of temperature fall speed, the effect of property stability may not be acquired at the temperature fall speed exceeding 20 degrees C/Hr. Moreover, although there is nothing especially about the minimum of a cooling rate what is restricted, since the effect of the further property stability does not show up at the temperature fall

speed of under 1 degree C / Hr but it becomes the fall of productivity rather, it is not effective.

[0013] About the flow and pressure requirement in the aforementioned specific temperature requirement, the upper shell which attains the purpose of this invention does not need to prepare an upper limit in the aforementioned pressure that what is necessary is to just be pressurized. However, if 200MPa is exceeded, it may be divided into porosity ceramic complex and cracking etc. may arise, it may be desirable, or at least less than 0.5 MPas may not have enough stabilization of a property, and 0.5MPa-200MPa will be chosen as a desirable range. Furthermore, 1-100MPa is chosen as best range practical.

[0014] Making molten metal cool and solidify in the porosity ceramic structure with a specific cooling rate under pressurization by the above-mentioned specific temperature requirement, and making low coefficient of thermal expansion and high temperature conductivity discover stably is not necessarily limited to sinking-in operation, but it can also apply sinking-in operation at once about the metal-ceramic complex pass. However, it is desirable to apply succeeding the processing which makes the inside of the temperature requirement of the specification of this invention a specific cooling rate under pressurization to sinking-in operation in respect of productivity. Furthermore, in the case of high pressure casting processes, such as pressure die casting which performs sinking-in operation under pressurization, and a forging cast process, it is good only by controlling temperature conditions, and it excels in operability and is desirable. Moreover, when applying sinking-in operation at once about the metal-ceramic complex pass, the above-mentioned processing can also be performed for the above-mentioned operation using an atmosphere pressurizer etc. under existence of non-reactivity gas phases, such as rare gas, such as an argon and helium, or nitrogen.

[0015] As long as the porosity ceramic structure of this invention is the structure which has the open pore which can infiltrate a metal or an alloy, and has the mechanical strength which moreover is not destroyed in sinking-in operation, what thing is sufficient as it. However, when applying metal-ceramic complex to the heat sink for semiconductor circuit substrates, since it being hard to fall in connection with a temperature rise and a coefficient of thermal expansion are said that a thing small to the same extent as the ceramic circuit boards, such as an alumina, alumimium nitride, and a silicon nitride, is required, it is high temperature conduction and a silicon carbide, alumimium nitride, a silicon nitride, an alumina, etc. of low coefficient of thermal expansion are suitable [ the thermal conductivity of metal-ceramic complex is high, and ].

[0016] Moreover, although thermal conductivity is smaller than the aforementioned ceramics, since the coefficient of thermal expansion is small, a silica has the feature that the coefficient of thermal expansion of metal-silica complex can be brought close to the coefficient of thermal expansion of a ceramic substrate with a few addition. Although it generally falls about metal-ceramic complex so remarkably that the ceramic content in this complex is large about the temperature dependence of the thermal conductivity, since the effect the complex obtained from the aforementioned feature using a silica has little decline in the thermal conductivity at the time of a temperature rise, and same as the time of using the aforementioned ceramics can be acquired, it is desirable too.

[0017] Since the metal-ceramic complex which has thermal conductivity higher [ the thermal conductivity of a silicon carbide of itself is higher than that of the aluminum which is the metal of high temperature conductivity among the ceramics mentioned above and ] than the thermal conductivity of the metal single taste when using a silicon carbide can be obtained, it is chosen especially preferably.

[0018] If the purpose of this invention can be attained, although it will be what thing and \*\*\*\*\* will not be cared about about the metal used for this invention, either, light alloys or those alloys, such as aluminum from the purpose which attains high temperature conductivity and lightweight nature, and magnesium, are desirable. In the case of an aluminium alloy, especially the alloy of 4 - 10% of AC2A and AC2B, AC4A, AC4B, AC4C, AC8B, AC4D, AC8C, ADC10, and ADC12 grade has the plain-gauze fibers for plastering of casting, and the point of a manifestation of high temperature conductivity to desirable Si content.

[0019] Especially the aluminum-silicon-carbide complex were using aluminum or the aluminum system alloy as a metal, and using the silicon carbide as ceramics about the above-mentioned ceramics and a

metaled combination, is the combination which was excellent in respect of the conformity of coefficient of thermal expansion with lightweight, high temperature conduction, and a ceramic substrate. As a result of examining many things further about this aluminum-silicon-carbide complex, this invention persons find out that the suitable range to give the purpose of this invention to a silicon-carbide content exists, and result in this invention. That is, a coefficient of thermal expansion is high at under 50 volume %, a bird clapper has a silicon-carbide content in aluminum-silicon-carbide complex, and it becomes easy to produce the aforementioned problem which originates in a coefficient-of-thermal-expansion difference with a ceramic substrate in this case. Moreover, it results from ceramics reducing thermal conductivity at an elevated temperature, and in the case of the silicon-carbide content exceeding 80 volume %, when it uses as a heat sink of the circuit board for semiconductor loading, the problem that decline in thermal conductivity becomes remarkable becomes remarkable by the temperature rise by generation of heat from the semiconductor device at the time of real use etc. In order that the silicon-carbide content in aluminum-silicon-carbide complex may have desirable 50 - 80 volume % and may attain the aforementioned conditions from the above reason, 50 - 20 volume % is suitable for the porosity of the structure of a porosity silicon carbide.

[0020] Hereafter, based on an example and the example of comparison, this invention is explained still in detail.

[0021]

[Example] the silicon carbide of 50 micrometers of [example 1] mean particle diameters -- as a binder -- a silica sol -- solid-content concentration -- 5wt(s)% -- after mixing and carrying out press forming, it calcinated at 900 degrees C among air for 2 hours, and size 35mmx35mmx3mm and the porosity silicon-carbide structure of 40% of porosity were produced

[0022] next, metal mold with a bore [ of 50mm ], and a thickness of 25mm -- preparing -- this -- metal mold -- a hole with a depth [ an outside surface to ] of 20mm -- preparing -- this -- a hole -- inside -- metal mold -- the thermocouple for internal-surface thermometries was set the actual measurement heat this metal mold by the burner and according to the contact surface thermometer of the inside temperature of metal mold, and the metal mold in that case -- it checked that there was no difference in the measured value of the thermocouple for internal-surface thermometries

[0023] the above which held inside temperature at 710 degrees C by burner heating after preheating the aforementioned porosity silicon-carbide structure at 800 degrees C -- it put into metal mold, the pure aluminium fused at 900 degrees C was slushed into metal mold, the push rod was set, and it pressurized by the pressure of 100MPa

[0024] with a pressurization state -- cooling -- metal mold -- the strength of a burner was adjusted looking at the measured value of the thermocouple for internal-surface thermometries, the temperature fall speed from 710 degrees C to 660 degrees C was controlled to 10 degrees C/Hr, and pressurization was ended in the place which turned off the burner by 660 degrees C and was cooled to 100 degrees C at them

[0025] Three samples of aluminum-silicon-carbide complex were produced by the same method, and the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured. This result is shown in Table 1.

[0026]

[Table 1]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 1 - 1	2 0 5	$8.7 \times 10^{-6}$	3 0 2
実施例 1 - 2	2 0 3	$8.8 \times 10^{-6}$	3 0 5
実施例 1 - 3	2 0 6	$8.9 \times 10^{-6}$	3 0 1

[0027] Three samples of aluminium alloy-silicon-carbide complex were produced by the method as an example 1 that it is the same except being 800 degrees C, the temperature requirement by which the inside temperature of the metal mold at the time of casting of [example 2] molten metal controlled 627 degrees C and temperature fall speed measured the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex, and the melting temperature of an aluminum-6wt% silicon alloy and this alloy showed [ 627-577 degrees C and the metal ] the result in Table 2.

[0028]

[Table 2]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 2 - 1	1 9 6	$7.8 \times 10^{-6}$	3 6 0
実施例 2 - 2	1 9 3	$7.9 \times 10^{-6}$	3 6 2
実施例 2 - 3	1 9 5	$7.7 \times 10^{-6}$	3 5 8

[0029] Except [example 3] temperature fall speed being 20 degrees C/Hr, three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 2, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result was shown in Table 3.

[0030]

[Table 3]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 3 - 1	1 9 7	$8.1 \times 10^{-6}$	3 5 0
実施例 3 - 2	1 9 5	$8.0 \times 10^{-6}$	3 4 7
実施例 3 - 3	1 9 5	$7.9 \times 10^{-6}$	3 4 9

[0031] Except [example 4] pressures being 200MPa(s), three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 2, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 4 was obtained.

[0032]



[Table 4]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 4 - 1	2 0 1	$8.3 \times 10^{-6}$	3 4 5
実施例 4 - 2	2 0 4	$8.0 \times 10^{-6}$	3 4 8
実施例 4 - 3	2 0 3	$8.1 \times 10^{-6}$	3 4 6

[0033] Except [example 5] pressures being 0.5MPa(s), three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 2, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 5 was obtained.

[0034]

[Table 5]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 5 - 1	1 9 9	$8.1 \times 10^{-6}$	3 4 5
実施例 5 - 2	2 0 0	$8.0 \times 10^{-6}$	3 4 8
実施例 5 - 3	1 9 7	$7.9 \times 10^{-6}$	3 4 6

[0035] Except [example 6] pressures being 220MPa(s), three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 4, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 6 was obtained.

[0036]

[Table 6]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
実施例 6 - 1	1 9 2	$8.3 \times 10^{-6}$	3 4 5
実施例 6 - 2	1 9 0	$8.1 \times 10^{-6}$	3 4 8
実施例 6 - 3	1 8 0	$8.9 \times 10^{-6}$	3 3 2

[0037] [Example 1 of comparison] Except having carried out 10 degrees C/Hr and temperature fall speed of 600 degrees C or less for the temperature fall speed to 650 degrees C - 600 degrees C to more than 25 degrees C / Hr, three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 2, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 7 was obtained. As compared with the example 2, that thermal conductivity, a coefficient of thermal expansion, and

intensity are not stabilized became whether to be Ming.

[0038]

[Table 7]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
比較例 1 - 1	1 9 0	$8.1 \times 10^{-6}$	3 4 0
比較例 1 - 2	1 6 0	$8.9 \times 10^{-6}$	3 0 2
比較例 1 - 3	1 5 8	$9.2 \times 10^{-6}$	3 1 0

[0039] [Example 2 of comparison] Except having carried out 10 degrees C/Hr and temperature fall speed of 550 degrees C or less for the temperature fall speed to 600 degrees C - 550 degrees C to more than 25 degrees C / Hr, three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 2, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 8 was obtained. As compared with the example 2, that thermal conductivity, a coefficient of thermal expansion, and intensity are not stabilized became whether to be Ming.

[0040]

[Table 8]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
比較例 2 - 1	1 9 5	$7.9 \times 10^{-6}$	3 5 0
比較例 2 - 2	1 9 2	$8.0 \times 10^{-6}$	3 1 0
比較例 2 - 3	1 9 4	$7.9 \times 10^{-6}$	3 2 8

[0041] Except the [example 3 of comparison] temperature fall speed being 25 degrees C/Hr, three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 3, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 9 was obtained. As compared with the example 3, that thermal conductivity, a coefficient of thermal expansion, and intensity are not stabilized became whether to be Ming.

[0042]

[Table 9]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
比較例 3 - 1	1 8 8	$8.1 \times 10^{-6}$	3 5 2
比較例 3 - 2	1 5 2	$9.0 \times 10^{-6}$	3 1 3
比較例 3 - 3	1 6 0	$9.2 \times 10^{-6}$	3 0 1

[0043] Except the [example 4 of comparison] pressure being an ordinary pressure (0.1MPa), three samples of aluminium alloy-silicon-carbide complex were produced by the same method as an example 5, the thermal conductivity, the coefficient of thermal expansion, and intensity of the obtained complex were measured, and the result shown in Table 10 was obtained. As compared with the example 5, that thermal conductivity, a coefficient of thermal expansion, and intensity are not stabilized became whether to be Ming.

[0044]

[Table 10]

	熱伝導率 W / ( m · K )	熱膨張係数 1 / K	三点曲げ強度 M P a
比較例 4 - 1	1 4 8	$8.1 \times 10^{-6}$	3 4 9
比較例 4 - 2	1 8 2	$8.5 \times 10^{-6}$	3 2 8
比較例 4 - 3	1 5 7	$8.2 \times 10^{-6}$	3 1 6

[0045]

[Effect of the Invention] the metal-ceramic complex whose properties, such as thermal conductivity, a coefficient of thermal expansion, and intensity, were stable according to this invention -- the yield -- since it can manufacture highly, and it is stabilized and reliable metal-ceramic complex can be offered cheaply, it is very useful on industry

[0046] The metal-ceramic complex manufactured by the method of this invention is suitable as heat sink material of the ceramic circuit board as a radiator article of electronic parts from the point of the high temperature conductivity, low thermal-expansion nature, and lightweight nature.

[0047] The metal-ceramic complex of this invention is useful also for the charge use of metal alternative material in transportations other than [ the lightweight nature and dynamic property to ] a heat sink use, and an aeronautical-navigation field.

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[Translation done.]

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2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

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**CLAIMS**

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[Claim(s)]

[Claim 1] The manufacture method of the complex which is the manufacture method of the complex which sinks a metal into the porosity ceramic structure, and is characterized by sinking in within the limits of the congealing-point temperature of the aforementioned metal, and temperature higher 50 degrees C than the aforementioned congealing-point temperature under pressurization at the temperature fall speed of 1-20 degrees C/Hr.

[Claim 2] The manufacture method of the complex characterized by processing within the limits of the congealing-point temperature of the aforementioned metal, and temperature higher 50 degrees C than the aforementioned congealing-point temperature for the complex which comes to sink into the porosity ceramic structure in a metal under pressurization at the temperature fall speed of 1-20 degrees C/Hr.

[Claim 3] The manufacture method of the complex according to claim 1 or 2 characterized by the bird clapper from one or more sorts chosen from the group which the porosity ceramic structure becomes from a silicon carbide, alumimium nitride, a silicon nitride, an alumina, or a silica.

[Claim 4] The claim 1 characterized by a metal making either aluminum or magnesium a principal component, the manufacture method of complex according to claim 2 or 3.

[Claim 5] The claim 1 characterized by for the aforementioned porosity ceramic structure consisting of a silicon carbide of 20 - 50% of voidage, and the aforementioned metal making aluminum a principal component, a claim 2, the manufacture method of complex according to claim 3 or 4.

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[Translation done.]